PRELIMINARY NOTES ON THE RATE OF GROWTH AND ON THE DEVELOPMENT OF INSTINCTS IN SPIDERS.

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The following work[1] was taken up in the fall of 1898 for the purpose of determining how young spiders develop through the winter, what instincts or intelligence they may possess and when these appear.

In October I collected, on a vacant lot in Philadelphia, several hundred cocoons, in all probability *Argiope cophinaria*, as that was the adult spider most commonly found among the cocoons. Dr. McCook in his *American Spiders and Their Spinning Work* (7) has described the structure of these cocoons so exactly that I need not go into it here.

Although the spider probably has not an intelligence comparable to that found in higher animals, that it does possess complex instincts is evident in the making of the cocoon. Four kinds of silk, of as many colors, are found in each completed nest; the whole is shaded over with a fifth, which renders it less conspicuous, and it is moored to its place by a sixth, (see McCook, (7), Vol. II). Each kind of silk has its respective place, which never varied in all the cocoons I examined, although in some a layer was omitted. However these differences are produced, an instinct that guides its possessor through such intricacies is of a high order.

All the occupants of a single cocoon were in the same stage of development, and until November cocoons containing all stages, from the egg to the just-hatched embryo, were found. After November the eggs that had not hatched dried up.

GROWTH.

Before the time of Balbiani's work (1) in 1873, the development of Araneæ had been studied chiefly with regard to the exter-

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nal features by such writers as Herold (4), 1824; Rathke (10), 1842; Von Wittich (11), 1845; and Claparède (3), 1862. Balbiani (1) has given a detailed description of the early development, but does not describe completion of the abdominal organs. In 1880 Balfour (2) gave notes on the development from completion of segmentation to completion of thoracic organs, but gave nothing with regard to the eventual fate of yolk and the formation of intestine. In 1886 Locy (6) gave a very complete account of the development of *Agalena* from laying of the eggs to hatching of the embryo. He showed that the intestinal tract is still incomplete at time of hatching, and my observations tend to confirm this. Kishinouye (5), in 1891, made observations on *Lycosa* and *Agalena* from laying of the egg to hatching. He has not followed out the completion of the intestine.

In the works of the last two writers, it is difficult to determine whether by the term "hatching" they mean leaving the egg membrane or leaving the cocoon. Locy speaks of one moult before hatching in *Agalena* and Kishinouye says there are two or three moults before hatching in *Agalena* and *Lycosa*. In *Argiope* there was no indication of a moult before the leaving of the egg membrane, but there were two or three moults before the leaving of the cocoon. In this paper hereafter by "hatching" is meant the leaving of the egg membrane. My observations agree with those of the above writers in showing that the spider leaves the egg in a very embryonic condition, and that the intestine is not complete until just before or just after leaving the cocoon.

For the purpose of determining how the young spiders develop, I killed a number for sectioning from time to time through the winter. Picro-sulphuric acid gave the best results as a fixing fluid. Second to this was picro-acetic acid. Both require from twelve to twenty-four hours to kill, because the many little hairs on the body enclose a jacket of air which buoys the spider up and keeps the fluid from reaching the skin. It is very difficult to make stains penetrate the tissues and I found the following a very good method. Having removed the legs, or, in the case of very young spiders, pierced the abdomen with a fine needle, stain *in toto* in picro-hæmatoxylin for twenty-four hours. It may be necessary to harden in alcohol and again stain in picro-hæmatoxylin. Take up to seventy per cent. alcohol and stain for twelve hours in alco-

holic eosin. The picro-hæmatoxylin will penetrate the abdomen slightly if at all; but the eosin stains it fairly well. The best results were obtained by embedding in celloidin and paraffin and fixing on the slide with hot water.

Argiope cophinaria.

As early as November the cephalo-thorax is complete; the stomach and œsophagus, the nerve mass surrounding them, the blood vessels around the nerve mass, muscles, poison glands, pigment and eyes are fully developed and throughout the winter I observed no change in this part of the body. The abdomen is the reservoir for the great quantity of yolk which remains even after so much of the body is completed. The intestine and "liver" have not made their appearance in November, although all the other abdominal organs have. This entire space is filled with solid yolk masses divided by three main blood sinuses which run down from the heart. The heart is much compressed at this time, and has few corpuscles in it (Pl. IX, figs. 2, 3 and 4). In January the yolk masses begin to break up and are slightly absorbed. In February the intestine shows distinctly in section and the "liver" can be distinguished among the yolk masses. There is a decided change in the shape of the abdomen—from rounded to elongated, flattened dorso-ventrally. In March (Pl. IX, fig. 1) the alimentary canal is almost complete from mouth to anus. The mouth is lined on both upper and lower lip with chitinous ridges, which interlock to form a strainer. A large quantity of yolk still surrounds the intestine and is scattered among the abdominal organs. As the yolk masses diminish, movements are noticed. At first there is a mere waving of legs, then rolling and scrambling over each other, and finally a definite, though awkward, climbing along the threads of the cocoon. Increase in size is slight, and takes place very slowly after the spider leaves the egg-membrane. Then follows a period of slow-development, which lasts through the cold months and consists in absorption of yolk, increase in pigment and change in shape to that of the adult spider.

Agalena nævia.

In addition to the Argiopes there came into my possession the cocoon of *Agalena nævia* Hentz. These eggs were laid on October 10, 1898, and hatched November 15. Within two weeks after hatching these spiders were perfectly black, running about the box

in which the cocoon lay and making an irregular web all through it. Their activity was in striking contrast to that of *Argiope*. In the matter of spinning webs and climbing on them they were skilled acrobats, and behaved as if this had been their habit for months. At this time they did not eat and showed no fear of each other, although they became wildly excited and ran in every direction when the box was disturbed or anything was dropped into the web.

In a few days they began to eat and increased notably in size. From time to time I made camera drawings as the increase warranted (Pl. X, figs. 5–14).

When the spider is full-fed and about to moult, the skin is very tight and shiny; the abdomen seems out of proportion to the cephalo-thorax. After the moult, the actual increase in size seems slight. The expanse of the legs is greater, there is an increase in length and in width of the cephalo-thorax, but the abdomen is shrunken. As soon as the spider begins to eat again, it increases rapidly in size until the limit is reached, when a moult again occurs. It is possible that this increase is due to filling out of folds in the skin.

Development of Instinct.

There has been some discussion as to whether the spiders have, in any degree, intelligence. There have been many scattered anecdotes and marvelous tales, such as those related in *The Naturalist in La Plata*, that would credit the spider with intelligence; but careful scientific investigation tends to refute all such ideas and places the spiders among animals having complex instincts. The most valuable work that has been done along this line is that of George and Elizabeth Peckham (9) and Dr. McCook (7).

It is certain that young spiders gain nothing by imitation, for many of the most highly developed species lay their eggs in the fall and give them no further attention. In the spring, when the young leave the cocoon, and when they would be most benefited by the example of others, they separate and each, with its own inheritance of instincts and tendencies, starts out to do battle for itself. And yet here as elsewhere in the animal kingdom, one is impressed with individual differences, as will be shown later.

Among the hunting spiders (*Lycosidæ*), too, there is no chance for imitation. At the time when the young leave their mother's back they separate, as in the case of the weavers. This does not imply that the spider leaves the cocoon, or its mother's back, as skilled and as agile as she is. It must learn and practice to perfect itself.

As early as February, and long before it leaves the cocoon, young *Argiope* can spin a little drop line, but the line is short; it requires considerable stimulus, as shaking, to cause it to spin; the spinner in many cases seems unable to climb back, and when it does climb back it is with exceedingly clumsy efforts. The young hunting spider at an early age obeys its instinct to catch a moving gnat, but its first attempts are rarely successful, and for some time it is very awkward.

OBSERVATIONS ON ARGIOPE COPHINARIA, OCTOBER TO APRIL.

All during October, spiders were hatching, and at this time gave no indication of any sense except that of touch.

In November they had moulted once or twice, and were slightly more active when disturbed.

In December they were decidedly more active, but seemed not to notice light or heat.

In January development was very slow and no changes were observed.

In February most of the little spiders could be made to spin a little drop line by violently shaking the egg ball. They made awkward attempts to walk, and did not use their hind legs in guiding them along the threads of their cocoon. Off the cocoon silk they were perfectly helpless, soon became tired and lay with legs drawn up.

To try the effect of severe winter weather on young spiders outside of the cocoon, I placed a number of specimens in a little pasteboard box and left them in an open window of an unheated room. Some individuals were in the silk of the cocoon, others were not. The following observations were made. Unfortunately, the exact amount of cold to which these spiders were subjected was not determined. In the absence of such data the official records of the Weather Bureau of the minimum temperatures for the nights in question are given:

February 9.—Removed spiders from cocoon as described above

and exposed all night. Weather Bureau record, —1° F. (= — 18.3°C.).

February 10.—Still living and active when touched. Exposed again all night. Weather Bureau record, — 6° F. (= — 21° C.).

February 11.—Less active. Exposed all night. Weather Bureau record, — 6° F. (= — 21° C.).

February 12.—No change. Exposed all night. Weather Bureau record, 4° F. (= — 15.5° C.).

February 13–16.—No change. Exposed each night. Weather Bureau record, 7°, 9°, 11°, 21° F. (= — 13.8°, — 12.7°, — 11.6°,—6° C.).

February 17.—Seemed more active. No definite movement toward any point or return to the ball on the part of those not in the silk (36°F. = 2° C.).

February 18.—Several of those lying on bottom of the box and outside of the meshes of the silk dead; others not so active (32° F. = 0° C.).

February 23.—All spiders lying on bottom of the box and not in the meshes of the silk, dead, except three beneath the silk of the cocoon; these three very sluggish (37° F. = 2.7° C.).

February 24–27.—Less active each day; nearly all the spiders in the box died, including those beneath the silk. The lowest temperature was 26° F. (= — 3.3° C.), on the 25th.

March 1.—Four living in the silk of the cocoon.

March 6.—All dead.

From observations made since, it is probable that these spiders died, rather from their scattered condition, than from the cold.

As opening cocoons seemed to have no effect upon the occupants, to determine how they would behave if deprived of the cocoon entirely, I made these observations:

February 9.—A brood of spiders, clinging to the cocoon silk was removed from the cocoon and spread out in a glass globe. They showed plainly that they were disturbed. Some moved along the threads of the silk, although for the most part they simply waved their legs and rolled over each other, trying to form into little balls wherever a few were together. No attempt was made to return to the cocoon, although it hung still attached to the silk. Aphids were offered as food, but the spiders did not seem to see these; also water, but no attention was paid to it.

February 10.—A decided grouping into balls was noticed at points where most of the spiders happened to be as the silk was drawn out. Moved awkwardly, or waved their legs, when brought near heat. No attempt to spin. Turned the globe so that light fell on it differently, but this produced no effect.

February 11.—No difference in position of balls; balls somewhat larger; fewer spiders moving along the web; all resting with ventral side uppermost, but moving with dorsal side uppermost.

February 17.—I placed the globe so that rays from a lamp fell on some of the spiders, while others were in shadow; after thirty minutes there was activity among those exposed to light—a general tumbling and rolling over each other, but no definite movement toward the light or away from it. Activity evidently caused by the light, as those spiders in the shadow remained quiet, with ventral side up as before.

March 12.—Drew silk away from one of the groups, scattering some of the spiders; all moved actively, apparently trying to get into centre of the mass; in a few hours all the stragglers had gone back to the group; acted as if stiff from cold, although temperature was not low.

March 13–31.—No change in groups; most of the isolated spiders died.

April 1.—Still no attempt to weave webs.

April 2.—More active, and moved along web with less waving of legs, using hind legs as guides; soon formed into groups when scattered.

April 26.—Those spiders on outside of groups shriveled up.

At this time I took some of the spiders out on a sheet of paper and noticed that they moved away from anything touching them, but were not aware of an approaching object until actually touched.

On March 10 I opened twenty-six cocoons that had been kept in a locker all winter. In these all were dead except six from different cocoons. These six were further developed than those taken from cocoons earlier in the year, were more active and moved as if accustomed to using their legs. As they seemed able to take care of themselves, I put them into a glass box, where they had ample opportunity to weave, and made these observations. I put into the box the tops of two cocoons, which they soon moored to the

bottom, not as the result of a definite purpose, but of mere wandering before settling down. Two finally crawled into a bit of the silk still clinging to one of the tops.

March 11.—Moved at the least jarring; all hung, ventral side up, on individual threads from lid of box.

March 22.—Two dead, in same position as when alive.

March 23.—Four survivors not so active.

April 9.—Not so active.

April 10.—Third one dead.

April 11.—Three remaining dropped to bottom of box as soon as disturbed, lay motionless an instant, then ran actively about, finally returning to original position—suspended from lid.

April 18.—Offered water, which they drank eagerly; bodies seemed to swell. Still no attempt at regular web.

These observations indicate that during the winter months the young Argiopes change very little in any way. In most of the cocoons the spiders were all alive and active until March, when very few cocoons had any living occupants. This must have been due to the heat of the house, as the spiders were all shriveled in appearance. On March 14 I gathered twelve cocoons in a vacant lot, and found that in all of them there were hundreds of living spiders, all at the same stage of development as the ones living in the house all winter.

The question arises here, what may be the use of the cocoon? It can scarcely be for retaining animal heat, as the amount of heat generated by the young spiders must be extremely little; their abdomens are packed with yolk and there is very little muscular activity among them. If taken out of the cocoon they form into close balls, and those which are able to keep in the centres of these balls live just as well as those in the cocoons, while those on the outside dry up. If kept in stoppered bottles they all live as well as in the cocoon. The chief use of the cocoons seems to be to keep the spiders together and to prevent evaporation of moisture. I took a number of spiders from cocoons that had been indoors all winter and from others that had been out of doors all winter, gave them some cotton to burrow into, wrapped them in separate pieces of very thin cloth and hung them outside where they would be exposed to March snow and wind and April rain; yet those that had been indoors all winter lived and kept pace with those in the

cocoons until April 18. Those that had been out of doors all died except one. From April 18 to April 26 the weather was very dry and it became very warm where the spiders were hanging. In that time they all dried up except the one from the cocoon that had been out of doors all winter. This survivor was very active and seemed ready to leave the nest. Spiders in cocoons hanging in the same place were all active and healthy, although every cocoon had been opened. This shows that they can endure cold, wind and rain, for the snow packed in all over the little bags of cotton and cloth, melted and dried in the sun. Absorbent cotton was used, and it must have been saturated many times. The cocoon holds the little spiders together for the purpose, as I think, of keeping them moist, and prevents evaporation of that moisture. The silk furnishes a suitable support, as is shown by the fact that they soon grow weary in attempting to walk on a surface, and that without a place of attachment, moulting becomes a great difficulty. The cocoon also prevents their being scattered into unfavorable places by dashing rains and high winds. The view that the cocoon prevents evaporation is borne out by the later life of the spider; for as soon as it leaves the nest and begins an independent existence, abundance of water is absolutely necessary. A spider will live indefinitely without food, but without water it will survive only a few days. The cocoon, of course, protects the young spiders against numerous enemies—birds, wasps, toads, etc., some of which, however, often pierce the cocoon. The great majority of the cocoons of *Argiope* which I examined had been bored into, and in some the eggs were ravaged; but I failed to find any traces of parasites (see McCook, 7). In other species I have found ichneumons and I wondered at their absence here.

At first I thought the young spiders always kept the ventral side uppermost, but later found that they always keep the ventral side outwards. Why they maintain this position is an unanswered question. Removing a nest from the cocoon I placed it in a black bag and hung it in a recess where no light could enter. On taking the nest out, at intervals for weeks, I saw that all the spiders had the ventral side turned out, even those on the bottom. It is evident that light has nothing to do with this phenomenon. It is possible that respiration is facilitated by this position.

I have not been able to make any valuable tests as regards the

development of the senses in *Argiope*, since the spiders are never hungry nor thirsty, and the first of these conditions is very important in determining range of sight. Fear has been shown only in the case of the three spiders taken from the cocoon on March 10, when they dropped on being disturbed. The other spiders would not move away from an approaching object, and would even sit still and be eaten up by older spiders of other species. Tests for hearing and the sense of smell would also be useless because of this lack of motive.

Argiope, then, in April, is about ready to leave the cocoon, can drop itself from danger on a little line and drink water. It makes no attempt to weave a snare, to eat its fellows or anything else, has little more than a rudiment of fear, and if it sees, the stimulus arouses no response.

Observations on Agalena nævia.

As the specimens of *Agalena nævia* grew too active and independent to be kept in an ordinary box, I placed them in an olive bottle, where all their movements could be easily watched. About December 15, when put into the bottle, they showed unmistakable signs of fear and acted as if they were in a strange place, running excitedly here and there. I gave them a little corner of an envelope for a refuge and point to collect on. After an hour they were quieter and set about weaving an irregular web from side to side of the bottle. This web became denser from day to day, and showed little tunnels running through it. The tunnel is very characteristic of the adult of this species. No attention whatever was paid to the refuge. They could see at least an inch, and recognized each other as cannibals. I draw this conclusion, because I observed that they charged upon each other when they came within that distance. I could not measure these distances accurately, but preferred to make the distance less, rather than greater than it actually was, and I am sure it was no less. That they feared each other was evident from the way the pursued ran from the pursuer.

They ate aphids or one another indifferently, increasing notably in size from day to day, or shriveling up and dying. Until February 18 I allowed them to live together, the larger ones eating the smaller and less active, and many dying. At this time seven

only survived. I put each one into a separate bottle, 6.3 cm. high and 1.6 cm. wide. The bottles were lettered *a*, *b*, *c*, *d*, *e*, *f*, *g*. From day to day each spider was observed and notes recorded. They grew much more rapidly than *Argiope* and formed an interesting study of specific and individual differences, as well as of developing instinct. That these spiders also are able to endure cold is proved by the fact that on February 9 they were exposed to the same temperature as the *Argiope* spiders. The moisture in the bottle froze all over the inside, but the spiders, beyond being stiff, until they were taken into a warm room, were not at all affected. The following are the records that were made. The spiders were kept under conditions as normal as possible, under the circumstances, and their behavior under these conditions carefully noted.

SPIDER A.—This spider busied itself for three days spinning a web back and forth across the bottle.

February 21.—Afraid of a little fly offered as food. After a few minutes it made an attempt to catch the fly. After five or six attempts, it caught the fly by its hind legs; fly escaped and was recaptured a number of times; spider spread its spinnarets and made a motion as if to enshroud its prey and tried to push under the fly's wings to seize it by the abdomen.

February 22.—Decided increase in size of spider; skin tight and shiny; color lighter than that of the other spiders.

February 24.—Introduced a little globule of water; no attention paid to it; finally I guided it until two feet dipped into the water, but it would not drink; refused to eat.

February 28.—Placed the spider in a shallow box for drawing; very much frightened and climbed out five or six times, then began to weave a web, but, although it climbed to the edge many times, it merely fastened the web and returned to the box. It frequently rested and cleaned itself, as does an adult spider.

March 3–5.—Drank water eagerly, but refused to eat.

March 6.—Moulted.

March 7.—Seized small fly, when offered it, at once.

March 12.—Increase in size evident.

March 19.—Dead.

SPIDER B.—*February 18.*—This spider was seen circling around a black, winged aphis, occasionally approaching it from the rear,

as if to seize it. Beside the aphis and moved by every struggle, lay an old white spider skin. This the spider finally took hold of and tried to drag away. After fifteen minutes, it left the skin and for fifteen minutes more seemed undecided, then seized the aphis near the head and proceeded to eat it. This was the largest of the spiders and the one that I had noticed most frequently devouring aphides, as well as its own kin, in the olive bottle.

February 20.—Greatly increased in size.

February 21.—Leaped at once upon thorax of a little fly and proceeded to eat it.

February 22.—Notable increase in size; skin of abdomen shiny, tight.

February 23.—Web very evident half-way up the bottle, woven irregularly from side to side.

February 24.—Dropped a small fly into the web; spider greatly excited at once, but seemed unable to locate fly; ran to dead fly in the web, then to one above, and back to lower one. Settled down finally as if discouraged and made no further efforts even when fly came immediately beneath its feet.

February 28.—Removed to shallow dish for purpose of making a camera drawing; behaved much as A did under similar circumstances, but quieted down much sooner (Pl. X, fig. 10).

March 1–2.—Refused to eat.

March 3.—Moulted.

March 7.—Deftly seized a mosquito by the thorax.

March 10–11.—Body large and shiny.

March 12.—Unusually excitable (Pl. X, fig. 11).

March 17.—Dropped down on a line on being disturbed; never did so before.

March 18.—Offered two little *Argiopes*—evidently a new kind of prey; spider much excited; approached, circled around, drawing out web all about and over little *Argiope;* an evident but feeble attempt to enshroud the prey; did not guide the thread at all with the hind legs and wasted much silk by not touching prey; went away from the little spider and after a few minutes went to other one, which it seemed not to see before, and, without any encircling movements, ate it.

March 20–22.—Skin very tight and shiny; refused to eat.

March 23.—Had moulted in the night; refused to eat.

March 27.—Caught a mosquito and again made motions as if to enshroud it (Pl. X, fig. 12).

April 4.—I turned the bottle on its side; in time the spider came out of the bottle, walking away about two inches in an excited, jerky manner; touched it with a pencil and it instantly rushed into the bottle; did not come out again.

April 5.—Would not come out of the bottle of its own accord.

April 6.—Increase in size noticeable.

April 7.—Pattern on ventral side of abdomen very distinct.

April 10.—Ate a small fly, but refused an ant.

April 11.—Refused to eat.

April 12.—Moulted.

April 13.—Decided difference in pattern and general shape; now a long, slender spider, much more excitable; turned and ran quickly to bottom of bottle on least disturbance.

April 14.—Attacked an ordinary house-fly and seized it by the abdomen (Pl. X, figs. 13 and 14).

April 16–17.—Rapid increase in size.

April 18.—Returned to dead fly of April 14.

April 19.—Fixed itself at once on thorax of house-fly; made movements as if to enshroud it.

SPIDER C.—*February 21.*—Made attempts to catch a fly entirely too large for it.

February 23.—Very sluggish.

February 24.—Three anterior legs of left side seemed crippled and a white exudation appeared at their bases.

February 27.—Dead.

SPIDER D.—This was one of the most active and excitable of the spiders from the start.

February 21.—Offered a little fly twice as large as itself; sprang at it and seized one hind leg; fly struggled violently and finally escaped; spider seized it again by abdomen and held on until fly was exhausted and gradually shifted its own position until it had its cheliceræ fastened into the back of the fly's thorax; made weaving movements with the spinnarets.

February 22.—Noticeable increase in size.

February 24.—Introduced little globule of water; spider was moving about and finally wandered into water, which it drank with evident satisfaction; made some cleaning movements afterwards.

February 28.—Very active; would not stay in shallow dish as others had done, although put back many times (Pl. X, fig. 5).

March 4–5.—Moulted some time in the night; refused to eat.

March 7.—Offered larger fly; spider attacked at once and seized one hind leg; clung for several minutes; after fly was worn out, the spider ran about it, excitedly spinning a web in a circle around it, but not touching it; after some time, proceeded to eat it.

March 10.—Body large and shiny (Pl. X, fig. 6).

March 18.—Offered a little *Argiope;* recognized a new kind of prey; circled around and around, secreting silk, but very little of the web touched the *Argiope.*

March 20–22.—Skin very tight and shiny; refused to eat.

March 23.—Had moulted in the night; refused to eat (Pl. X, fig. 7).

April 11.—More excitable; went through usual winding movements before eating (Pl. X, fig. 8).

April 14.—Had become expert at catching prey.

April 15.—Body very large; skin tight and shiny (Pl. X, fig. 9).

April 18.—Moulted.

April 19.—Looked exactly like B; more excitable than ever; still made movements with spinnarets on catching prey.

SPIDER E.—This was an active little creature, although one leg was missing on the right side.

February 21.—Made a number of attempts to catch a fly; finally seized it by a hind leg; settled down on fly's thorax; after twenty minutes began to weave a web with fly as a centre; moving the bottle did not disturb the worker; after eating there was a distinct, but awkward, attempt to clean itself.

February 27.—Noticeable increase in size.

February 28.—When removed to shallow dish, made efforts to escape, but after five or six trials began to weave a web contentedly.

March 2.—Dead; posterior abdomen white.

SPIDER F.—This was the smallest and weakest spider.

February 21.—Two hind legs on right side crippled; made unsuccessful attempt to catch a fly.

February 22.—Dead.

SPIDER G.—*February 21.*—Became excited when offered a fly, but began to weave a web and paid no further heed, even when fly walked over it.

February 22.—Made several attempts to catch a fly; finally succeeded.

February 23.—Dead.

In reading over these records of *Agalena nævia*, one is at first impressed with the small number of survivors, but we must remember that they were not under perfectly normal conditions. Had they been out in the fields, they would not have had so good an opportunity to kill each other, but their enemies would have had a better chance to prey upon them. In the bottles they were protected from storms, but were more liable to disease. Whether these factors counterbalance each other remains a question. These records also indicate that the spider's early life is greatly influenced by the quantity of food and by individual as well as specific differences. Some of the spiders are distinguished from the outset by size, strength or quickness, and these are thus able to provide themselves with more food and grow accordingly. When the spiders were well fed the moults occurred closer together, although they will moult or make the attempt to do so, after a long time when food is scarce.

At first these spiders were all fed on aphides which they relished, but as they grew larger and were offered other things, the aphides were refused. Flies were eagerly caught, but ants were never touched. This would indicate that they have some kind of discrimination.

Another very interesting phenomenon has been the attempt to enshroud prey. From watching these movements many times, I am sure it is an instinctive impulse they attempt to obey, and which is utterly useless because imperfectly performed. Adult spiders that have this habit hold the victim firmly in their jaws and twirling it around, wind it in a web drawn from the abdomen by the hind legs. *Agalena* does not have this habit when adult, but drags its prey into a tunnel. The young were frequently seen attempting to drag the struggling flies, although they had made no regular tunnels in their webs. The attempt to enshroud must be the result of an instinctive return to a habit that is lost.

Summary.

1. Growth is gradual through regular, successive stages, which follow each other rapidly or slowly, according to the species and the individual.

2. Increase in size takes place chiefly between the moults and is largely dependent on the food.

3. Moulting does not occur at regular intervals after the spiders leave the cocoon, but according to the amount of food.

4. Sensory reactions to external stimuli are poorly developed in the very young animals, and are not manifested until the spiders seem ready to put them to immediate use. They then develop and become more acute with practice. The earliest reactions to appear can be interpreted as fear.

5. Although at an early stage distinction between light and darkness is possible, distinction between objects is not.

6. Cannibalism does not appear while the young are in the cocoon, although in *Agalena* it is a marked characteristic afterwards.

7. Young spiders can withstand a very cold, moist atmosphere, but not a warm, dry atmosphere.

8. Young *Argiope* always rest with the ventral side uppermost when isolated; the ventral side is turned outwards when the spiders are in a ball or group.

9. The cocoon prevents evaporation of moisture and serves as a support for the young spiders, and, to a less extent, as a protection against enemies.

10. Young spiders differ in growth and habits, specifically and individually.

11. Those instinctive reactions which are most advantageous to the species become habitual through repetition and selection.

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EXPLANATION OF THE PLATES.

PLATE IX.

Fig. 1. Longitudinal section of abdomen of *Argiope cophinaria* in March; approximate age, five months. Reichert oc. 2, obj. 7a.

Fig. 2. Longitudinal section of *A. cophinaria* in November; approximate age, one month. Reichert oc. 2, obj. 3.

Fig. 3. Longitudinal section of cephalothorax of *A. cophinaria* in November. Richert oc. 2, obj. 7a.

Fig. 4. Longitudinal section of abdomen of *A. cophinaria* in November. Reichert oc. 2, obj. 7a.

PLATE X.

Figs. 5–11. Outlines of cephalothorax and abdomen of *Agalena nævia*, "d" and "b," × 9.

Fig. 5. "d," February 28, age 105 days from hatching, length of body 2.2 mm.

Fig. 6. "d," March 14, age 119 days, length 2.28 mm.

Fig. 7. "d," March 23, age 128 days, length 3 mm.

Fig. 8. "d," April 11, age 147 days, length 3.65 mm.

Fig. 9. "d," April 15, age 151 days, length 4 mm.

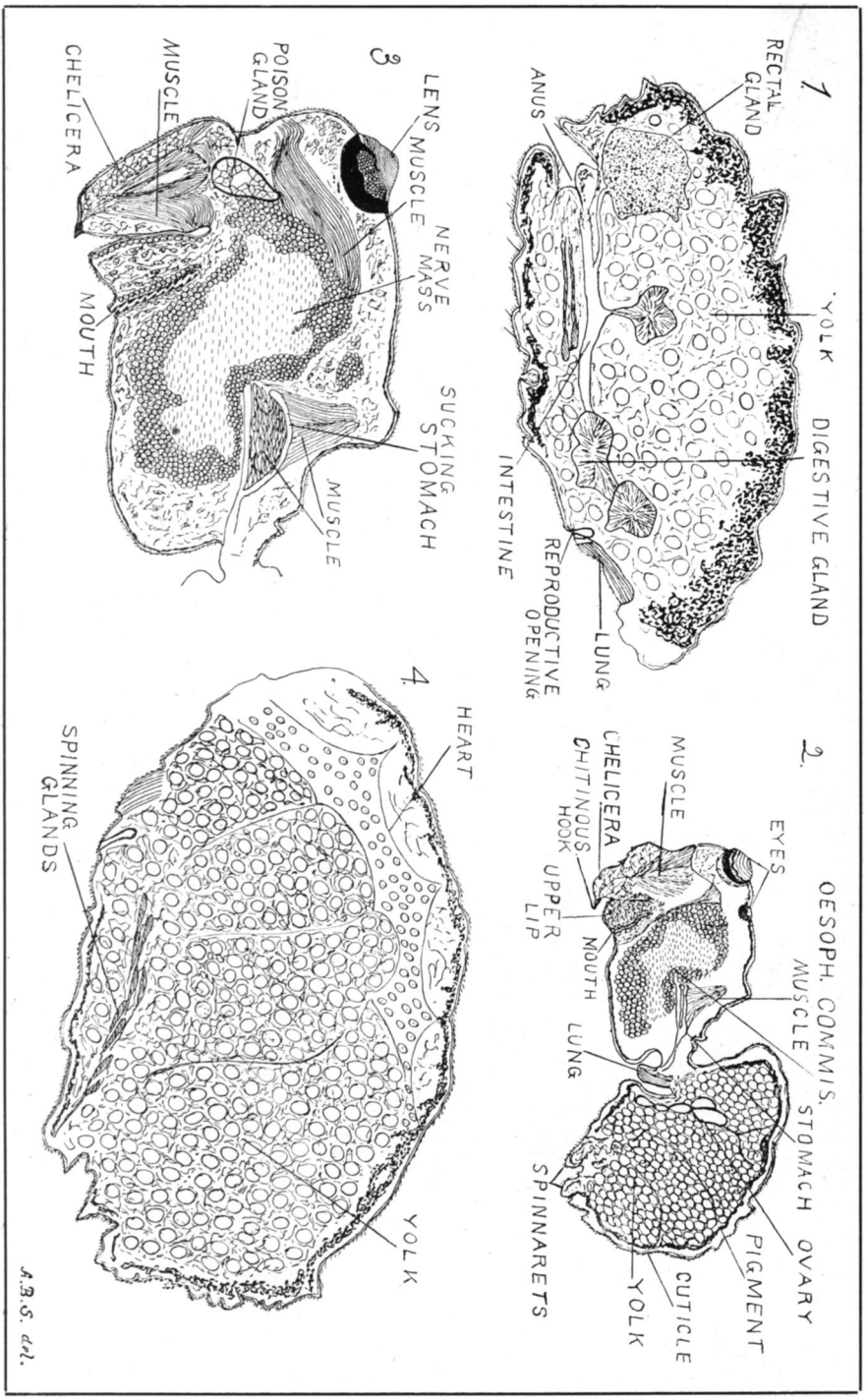
Fig. 10. "b," February 28, age 105 days, length 2.36 mm.

Fig. 11. "b," March 14, age 119 days, length 3.5 mm.

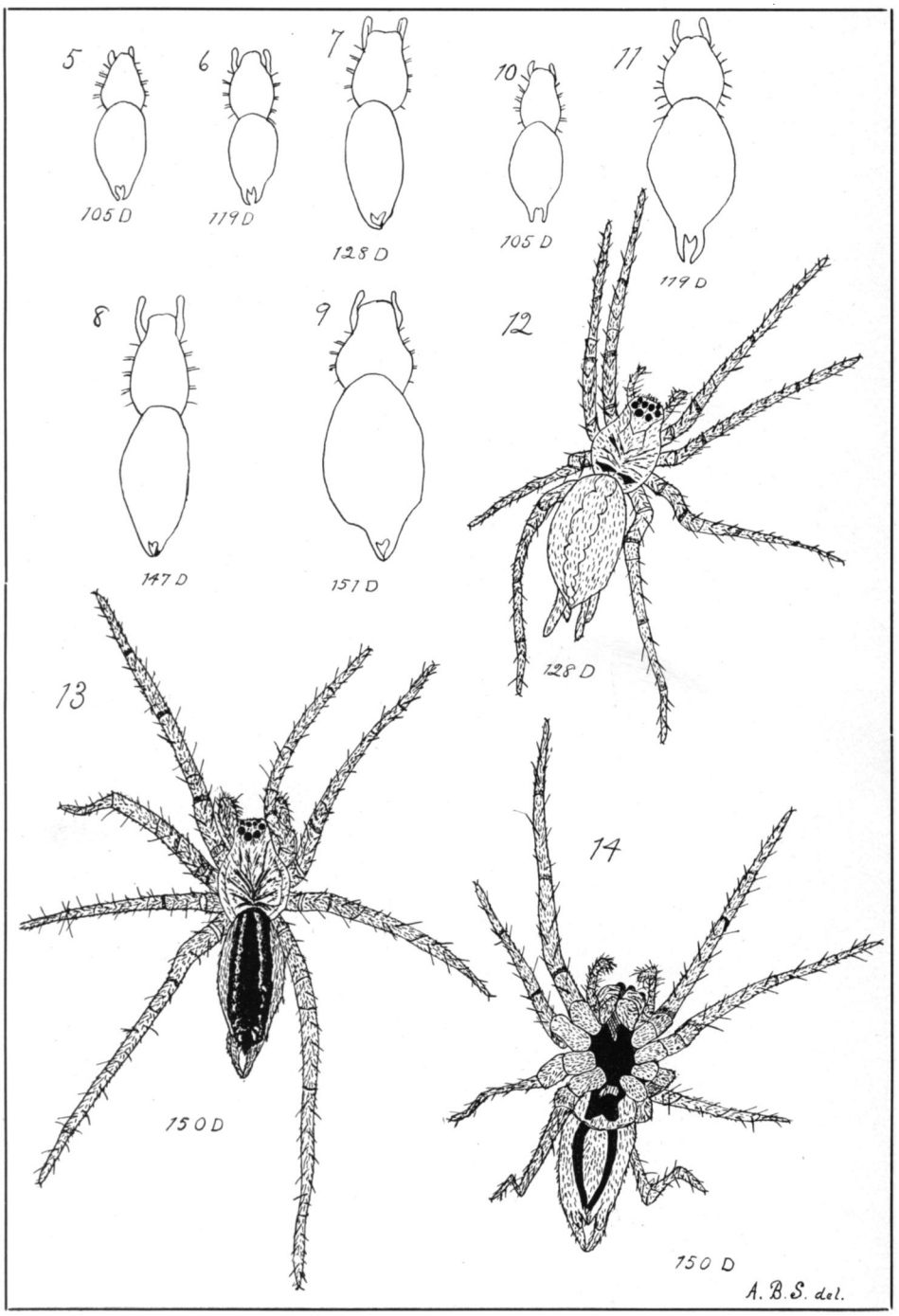
Fig. 12. *A. nævia*, "b," dorsal view, March 23, age 128 days, length of body 4.5 mm. × 7.

Figs. 13 and 14. Dorsal and ventral views respectively of *A. nævia*, "b," April 14, age 150 days, length of body 5 mm. × 7.

All the figures 1–14 are from camera drawings.



SARGENT. DEVELOPMENT OF SPIDERS.



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